SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JUNE 1903.

GENERAL PHYSICS.

612. *Dissipation Function of a Viscous Fluid.* **L. Natanson.** (Acad. Sci. Cracovie, Bull. 8. pp. 488–494, Oct., 1902.)—The author begins by investigating a perfectly general definition of the dissipation function of a fluid, and he finds for it first the following expression, equation (5) in his notation—

$$\chi=(p_{xx}-p)e+(p_{yy}-p)f+(p_{zz}-p)g+p_{yz}a+p_{zx}b+p_{xy}c,$$

in which p_{xx}, &c., are the normal, and p_{yz}, &c., the tangential components of pressure, p is the mean pressure, $e, f, g=\frac{du}{dx}, \frac{dv}{dy}, \frac{dw}{dz}$, and $a=\frac{dw}{dy}+\frac{dv}{dz}$, $b=$&c., $c=$&c. Substituting Stokes's notation—

$$p_{xx}-p=-2\mu e-\lambda\tilde{\omega},\quad p_{yz}=-\mu a,\ \text{\&c.},$$

λ and μ being two new constants, and $\tilde{\omega}=e+f+g$, he finds—

$$\chi=-2\mu\left(e^2+f^2+g^2+\frac{a^2+b^2+c^2}{2}\right)-\lambda\tilde{\omega}^2,$$

the expression obtained by Stokes. Introducing the conception of "relaxation" due to Poisson, and writing T for the time of relaxation, he finds a second expression ((7) in his notation)—

$$\chi=\varepsilon^{-t/T}\left\{(p^0_{xx}-p^0)e+(p^0_{yy}-p_0)f+(p^0_{zz}-p^0)g+p^0_{yz}a+p^0_{zx}b+p^0_{xy}c\right\}$$
$$-\left\{2\mu(eE+fF+gG)+\mu(aA+bB+cC)+\lambda\tilde{\omega}(H)\right\},$$

in which p^0_{xx}, &c., denote the values for $t=0$; also—

$$E=\varepsilon^{-t/T}\int\frac{dt}{T}\varepsilon^{t/T}e,\quad F=\text{\&c.},\quad G=\text{\&c.}$$

$$A=\varepsilon^{-t/T}\int\frac{dt}{T}\varepsilon^{t/T}a,\quad B=\text{\&c.},\quad C=\text{\&c.}$$

and—

$$(H)=E+F+G.$$

This is the dissipation function according to the author's own theory. He then proves a theorem about this dissipation function. It is assumed that the incompressible viscous fluid in question undergoes very slow deformations, so that the kinetic energy of its motion is always negligible, also that there are no external forces acting. Under these circumstances the equation of energy gives—

$$\int\int dS(uP_x + vP_y + wP_z) + \int\int\int d\Omega x = 0,$$

in which $d\Omega$ is an element of the volume occupied by the liquid, dS an element of its bounding surface, and P_x, P_y, P_z the components of external pressure on dS, and differentiating this expression he gets in the usual notation—

$$\frac{d}{dt}\iint dS(uP_x + vP_y + wP_z) + \iiint d\Omega \frac{dx}{dt} - \iint dS(lu + mv + nw)\chi = 0.$$

Again, differentiating the second expression (7), he obtains—

$$\frac{d\chi}{dt} = -\frac{\chi}{T} - \frac{2\mu}{T}\left(e^2 + f^2 + g^2 + \frac{a^2 + b^2 - c^2}{2}\right).$$

The second term of the right hand member of this equation represents χ according to the theory of Poisson and Stokes. If this be denoted by ζT, we have $\frac{d\chi}{dt} + \frac{\chi}{T} + \zeta = 0$. This makes apparent the distinction between the author's theory and the Poisson–Stokes theory. The memoir concludes with an analogous proposition taken from the theory of elasticity. S. H. B.

613. *Deformation of a Plastic Viscous Disc.* **L. Natanson.** (Acad. Sci. Cracovie, Bull. 8. pp. 494–512, Oct., 1902.)—In this second memoir the author states the following problem: The substance considered, an incompressible fluid, is between two rigid horizontal planes, of which the lower is fixed. The upper is movable and may be weighted, or otherwise communicate homogeneous pressure to the substance. Laterally the substance is subject to atmospheric pressure only. It is assumed that there can be no sliding of molecules of the substance over the bounding surfaces. He proposes to consider the deformation.

Obermayer had treated the same problem in 1877 by the experimental method. The writer begins by making certain further assumptions, namely, that the substance may be treated as a viscous fluid obeying the laws of Xavier, Poisson, and Stokes. If X Y Z are the components of external force, μ, λ the constants of viscosity, and $\tilde{\omega} = du/dx + dv/dy + dw/dz$, we have—

$$\rho\left(\frac{du}{dt} - X\right) + \frac{dp}{dx} - \mu\nabla^2 u - (\lambda + \mu)\frac{d\tilde{\omega}}{dx} = 0.$$

Then he makes the further hypothesis that $X = Y = Z = 0$, which involves the consequence that the terms $\rho\frac{du}{dt}$, &c., and $\tilde{\omega}$ are negligible. The equation so becomes $dp/dx - \mu\nabla^2 u = 0$. He then assumes the deformation to be symmetrical about the vertical axis of z, and, following Stefan and Obermayer, defines $u = Jxz(l - z)$, $v = Jyz(l - z)$, where l is the distance between the planes, and J is independent of $x\ y\ z$. Hence he deduces—

$$w = -Jz^2\left(l - \frac{2}{3}z\right), \quad J = -\frac{3}{l^3}\frac{dl}{dt}$$

These are the fundamental conditions on which the problem is worked out.

If π denote the mean pressure per unit of surface on the upper plane, R, the radius of the upper plane (the mass being supposed cylindrical), he finds—

$$\pi = -\frac{3\mu}{l^3}\left(l^2 + R_0^2\left(\frac{l_0}{l}\right)^2 - \frac{1}{2}\right)\frac{dl}{dt},$$

l_0 being the initial value of l, R_0 that of R the radius of the middle section. Stefan's solution of this problem was—

$$\pi = -\frac{3}{2}\mu\frac{R_l^2}{l^3}\frac{dl}{dt}.$$

In the second section he attacks the problem by a different route, which leads to Stefan's equation, assuming $3z^2(l - z^2)$ to be neglected.

He then, section (3), discusses the effect of abandoning certain of the restrictive hypotheses above made. First he abandons that of incompressibility, and obtains new values of π. In section (4) and the following sections he discusses the question whether a viscous fluid, compressible or incompressible, subject to the laws of Poisson and Stokes, can properly represent the properties of bodies known as plastic, and expresses doubts. He investigates the problem afresh from the point of view of his own theories, developed in many previous memoirs. In conclusion he finds—

$$\frac{d\pi}{dt} + \frac{\pi}{t} + \frac{3}{2}\frac{nR^2}{\lambda^3}\frac{dl}{dt} = 0,$$

where n is the modulus of rigidity, which is a generalised form of Stefan's equation. But Stefan's equation, as above given, implies the constancy of π. That, according to the writer, is because the ordinary theory of viscosity takes no account of the fact that the time of relaxation is finite, and therefore gives a correct solution of the problem under discussion only when the pressure π is constant. In the last section he supposes the thickness l to be maintained by the experimenter constant, whence $\pi = \pi^0\epsilon^{-t/T}$. That would make evident at sight the essential defects of a theory which makes the time of relaxation infinite. From the application to this case of the results of the preceding memoir he comes to the conclusion that by experiments made under the last described condition it is possible not only to determine the coefficient of internal friction, as Obermayer has done, but also the duration of the time of relaxation. S. H. B.

614. *Molecular Dynamics of a Crystal.* **Kelvin.** (Roy. Soc. Edinburgh, Proc. 24. pp. 205–224, Nov., 1902.)—This is a sequel to the author's paper on the molecular constitution of matter, read before the Royal Society at Edinburgh in July of 1889, and reprinted in vol. iii. of the author's "Mathematical and Physical Papers." In this, and the previous paper, the author applies the Boscovitch equilibrium theory of elastic solids to the dynamics of crystals. The method adopted is to determine the amount of work w required to separate all the atoms of the crystal to infinite distances from each other. Each molecule may be a single atom or it may consist of a group of atoms. In the present paper the atoms are supposed to be of identical quality, and only two kinds of assemblage are considered: (1) A homogeneous assemblage of N single atoms, in which the twelve nearest neighbours of each atom are equidistant from it. This the author calls an equilateral assemblage. (2) Two simple assemblages of N/2 single atoms, placed together so that one atom of each assemblage is at the centre of a quartette of nearest neighbours of the others. In each of these cases w is the same for all the atoms, except the negligible number of those within influential distance of the boundary. The work w is expressed as a function of the distance λ which forms the basis of the homogeneous assemblage; in (7) it is the side of an equilateral triangle. The author observes that it will be an interesting further development of the molecular theory to find some illustrative cases of chemical compound molecules which are, and others which are not, in stable equilibrium at some density or densities of *equilateral* assemblage. He points out that the mathematical theory requires development in respect to the conditions for stability. This problem is considered for two simple cases. (1) Take a group of eight particles at the corners of a cube mutually acting on one another with forces all varying according to the same law of distance. Assume the magnitudes of the forces such as to produce equilibrium, and let their law of variation be such as to make the equilibrium stable. Suppose a crystal to be built up of such cubes, and suppose that each atom is composed of the eight particles in contact which will be found in such a structure. (2) The case of the equilibrium of an infinite row of similar particles free to move only in a straight line. G. W. DE T.

615. *Theory of Diffusion.* **M. Thiesen.** (Deutsch. Phys. Gesell., Verh. 4. 15. pp. 348–360, Oct. 31, 1902.)—The writer proposes to show that the diffusion of two simple gases depends on four constants, but that these constants can, to a high degree of probability, be deduced from the definition of the friction coefficients (Reibungscoefficienten). For liquids or imperfect gases the relations are more complicated, and the theory is probably not applicable to the phenomena of friction in such cases. He supposes a system of free molecules in which a certain molecule is initially near the origin of coordinates, and he discusses the chance, namely $f(x, t)dv$, that after time t it shall be within an element of volume dv distant x from the origin, and he finds $f(x, t)e = Ae^{-Br^2}$. Similarly, for a distance r in any direction, $F(r, t) = A^3e^{-Br^2}$ with the relation $\pi A^2 = B$. Then using a proposition due to Stanzel [see Abstract No. 1992 (1902)] he deduces—

$$f(x, t) = \frac{b}{\sqrt{\pi t}} e^{\frac{-b^2x^2}{t}} \text{ and } F(r, t) = \frac{b^3}{\sqrt{\pi^3 t^3}} e^{\frac{-b^2r^2}{t}}$$

b being a constant depending on the nature of the molecules. Considering, then, a medium composed of molecules of one kind he takes $\phi(xyzt)$ to denote the density at xyz at time t, and he finds—

$$\phi(x, y, z, t) = \iiint_{-\infty}^{+\infty} F(r, t)\phi(\xi, \eta, \zeta, 0)d\xi d\eta d\zeta$$

ϕ satisfies the differential equation, $4b^2d\phi/dt = \Delta^2\phi$ (12), or if the density varies only in x, $4b^2d\phi/dt = d^2\phi/dx^2$. Then the assumption is made that, initially $\phi(x0) = C - Dx$, or 0, according as x is negative or positive, and he deduces (changing the sign of ξ)—

$$\int^{\infty} \phi(x, t)dx = \frac{C}{2b}\sqrt{\frac{t}{\pi}} + \frac{Dt}{8b^2}$$

If we had made the assumption that $\phi(x0)$ becomes 0 for x negative, and $(C - Dx)$ for x positive, we should have the same result with D negative. Combining the two, we have for the stream velocity in x, $u = 1/4b^2 . d\phi/dx$, if ϕ be a linear function of x. At this point he drops the restriction on ϕ that it is a linear function, substituting the condition that the time considered is very short, and also the restriction that the molecules are all of one kind ; but the space considered must in that case also be very small. *b* will now be variable, and he gets the more general differential equation—

$$\frac{d\phi}{dt}=\frac{d}{dx}\left(\frac{1}{4b^2}\frac{d\phi}{dx}\right)+\frac{d}{dy}\left(\frac{1}{4b^2}\frac{d\phi}{dy}\right)+\frac{d}{dz}\left(\frac{1}{4b^2}\frac{d\phi}{d^2}\right)\text{............}(16)$$

This is the equation to be satisfied by a quantity ϕ, which is distributed, but not otherwise affected by the stream, the molecules being its carriers. If, further, the distribution of the molecules themselves is unaffected by the quantity ϕ, which they carry, the equation to be satisfied is (12). This last assumption is satisfied, he says, in the theory of friction, in which ϕ is a velocity, and, for one kind of gas, if η be the coefficient of friction, δ the density $4b^2\eta=\delta$. If there be two kinds he gets $\frac{1}{b^2}\frac{d\phi}{dx}=\frac{1}{b_1^2}\frac{d\phi_1}{dx}+\frac{1}{b_2^2}\frac{d\phi_2}{dx}$, in which b_1, ϕ_1 relate to one, and b_2, ϕ_2 to the other. Next he considers the case in which, not velocity, but heat is the quantity carried. Here he finds $\delta c=4b^2\kappa$, in which c is specific heat, and κ conductivity. Finally he considers the case of diffusion between two chemically distinct substances. Here b is not constant, and the medium not homogeneous. He shows that the equation 16 is not always applicable to such a case, because the mixing of the two substances is generally accompanied by change of volume. Writing x' for the stream velocity, he now obtains—

$$\frac{d\phi_1}{dt}=\frac{d}{dx}\left(\frac{1}{4b_1^2}\frac{d\phi_1}{dx}-\phi_1x'\right),\quad \frac{d\phi_2}{dt}=\frac{d}{dx}\left(\frac{1}{4b_2^2}\frac{d\phi_2}{dx}-\phi_2x'\right).$$

The volume before mixing is given in terms of the volume after mixing as $\zeta=m_1\phi_1/\delta_1+m_2\phi_2/\delta_2$, $m_1\,m_2$ being the masses of the two kinds of molecules respectively. And finally, making $\zeta=1$, he obtains—

$$\frac{d\phi_1}{dt}=\frac{d}{dx}\left\{\frac{1}{4b_1^2}-\frac{m_1\phi_1}{\delta_1}\left(\frac{1}{4b_1^2}-\frac{1}{4b_2^2}\right)\right\}\frac{d\phi_1}{dx}$$

According to the theory of Berthollet and Fick, the expression in brackets in the last equation should be constant. This, our author says, is only approximately correct. Again, b^2 is a resistance, and assuming the resistance of the mixture to be the sum of the resistances due to its components, we may write $4b_1^2=a_{11}\phi_1+a_{12}\phi_2+$ &c., whence applying the formula $4b^2\eta=\delta$ he finds $\eta_1=\delta_1/a_{11}\phi_1=m_1/a_{11}$, expressing Maxwell's law that the coefficient of friction for gases is independent of the density. He concludes with remarks as to the experiments that might be made with advantage. The elastic sphere theory of gases, and also the hypothesis of the inverse fifth power, he considers to be now only useless encumbrance. S. H. B.

616. *Remarkable Sunsets at Nice.* **Perrotin.** (Comptes Rendus, 135. pp. 724–726, Nov. 3, 1902.)—At the Bischoffsheim Observatory near Nice red and pink sunsets were noticed on October 27–30 ; the sky was clear and favourable only on the last day. The maximum effect was observed about 45 minutes after sunset, and the phenomenon lasted 1½ hours. On Nov. 1 the red sunset was already much less noticeable, and the glow had shifted towards the north. The author draws attention to the fact that the Krakatoa sunsets of 1883, which extended to the same elevation of about 50 km., were also noticed in the last days of October. H. B.

617. *Remarkable Sunsets and Sunrises at Bordeaux.* **E. Esclangon.** (Comptes Rendus, 135. pp. 846–848, Nov. 17, 1902.)—Peculiar red or pink sunsets were first noticed on October 23, and they became very brilliant on October 27–30 with a clearer sky. By November 3 the sunset phenomenon had disappeared, and the sunrises now became remarkable. At the same time the temperature rose suddenly from 6·3° C. on November 2 to 11·3° C. on November 3, and this warm wave, with temperatures up to 17° C., continued till November 8. Like Perrotin [see preceding Abstract], the author therefore considers the phenomenon to be of meteorological rather than of volcanic character. H. B.

618. *Elasticity and Hardness of Different Kinds of Iron.* **C. Bach.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 1536–1539, Oct. 11, 1902.)—These were examined at about 21° C., and the elasticities E, limiting stresses L, and breaking stresses K, were found as follows, stresses σ being expressed in kg. wt. per sq. cm. :—

	E.	L.	K.	
Weld iron	2,085,500	2,136	3,469	mean of 2 specimens
Ingot iron	2,166,700	3,161	4,413	,, 3 ,,
Ingot steel	2,208,500	4,188	6,906	,, 2 ,,
Cast iron (1)	70,608,000 $\sigma^{-1\cdot691}$		1,413	,, 3 ,,
,, (2)	16,046,000 $\sigma^{-1\cdot378}$		1,947	,, 2 ,,
,, (3)	8,123,000 $\sigma^{-1\cdot260}$		2,399	,, 3 ,,

The chemical analyses of the specimens examined are given in the paper. R. E. B.

619. *Gravitation in France.* **J. Collet.** (Comptes Rendus, 135. pp. 774–776, Nov. 10, 1902.)—The author discusses the determinations of pendulum observations which he, in conjunction with Mme. Collet, has been making since 1893 at twelve stations along or near the 45° lat., which passes through Bordeaux, Grenoble, and Turin; figures for Paris and Marseilles are comprised in the table. The observations were made after the method of Defforges, and the discussion concerns only the reliability of the results. H. B.

620. *Rainfall in Madras and Sunspot Frequency.* **M. B. Subha Rao.** (Monthly Weather Rev. 30. pp. 438–440, Sept., 1902.)—The year 1900 was very hot in the city of Madras, and both 1899 and 1900 were very dry. Hot years are generally dry years there, but there were nine exceptions, years with heavy rainfalls, between 1870 and 1900. Minimum rainfall years coincide with minimum sunspot years; the agreement between maximum rainfall years and maximum sunspot frequency is less marked. The tables go back to 1811. In 1900 the wind direction was abnormal. H. B.

621. *Solar Parallax and the Velocity of Light.* **Perrotin.** (Comptes Rendus, 135. pp. 881–884, Nov. 24, 1902.)—Seventeen series of measurements were made of the velocity of light by Fizeau's toothed wheel method, the total distance travelled by the light beam being 92 km. The weighted mean of 1,109 observations gave as the velocity of light in vacuo 299,860 ± 80 km.;

this differs but slightly from a previously found value of 299,900 ± 80 km. [see Abstract No. 42 (1901)], and from these two values a final mean is obtained of 299,880 ± 50 km. From this number and a determination of the solar parallax, 8″·805 ± 0″·011, determined by observations of Eros, the coefficient of annual aberration was found to be 20″·465, which is the same as Lœwy and Newcomb's value adopted by the international conference.

E. C. C. B.

REFERENCES.

622. *Physical Dimensions.* **N. A. Hesehus.** (Phys. Zeitschr. 3. pp. 561–565, Sept. 15, 1902. From the "Iswestija" of the St. Petersburg Technolog. Inst.)—The author discusses the consequences of certain assumptions. A. D.

623. *Practical Application of Fourier's Series to Harmonic Analysis.* **R. W. Prentiss.** (Phys. Rev. 15. pp. 257–270, Nov., 1902.)—The paper consists of a scheme and tables by means of which curves involving frequencies of from 1 to 5, 1 to 11, or 1 to 17 times the fundamental may be analysed mechanically and with comparatively little labour, without any knowledge of the theorem being required.

G. W. de T.

624. *Weights of Atoms.* **Kelvin.** (Phil. Mag. 4. pp. 177–198, Aug., and pp. 281–301, Sept., 1902.)—This is an extended reprint of one of the author's Baltimore lectures, and gives a critical review of the principal researches which have thrown light on the dimensions of the molecular structure of matter.

G. W. de T.

625. *Liquid Drops and Tate's Law.* **A. Leduc** and **P. Sacerdote.** (Comptes Rendus, 135. pp. 732–733, Nov. 3, 1902.)—This is a reply to the criticism of Guye and Perrot [see Abstract No. 378 (1903)]. It is pointed out that the drops were always formed slowly in the experiments criticised; and that the results do not verify Tate's law, but rather show the restricted limits of this law. [See also Abstract No. 3 (1903).] J. W. P.

626. *Simple Foucault Pendulum.* **d'Arsonval.** (Comptes Rendus, 135. pp. 832–833, Nov. 17, 1902.)—A description of a simple form of the apparatus, by Cannevel, which works well and costs only 20 francs. J. W. P.

627. *Propagation of Elastic and Electromagnetic Waves in Uniaxial Crystalline Media.* **J. Grünwald.** (Akad. Wiss. Wien, Sitz. Ber. 111. 2a. pp. 411–485, 1902.) —A mathematical paper which solves, for uniaxial crystalline, media the problem (1) of propagation of a prescribed initial condition of the medium in the absence of external disturbing influences, and (2) of the wave-motion excited, by given external disturbing effects, in a medium initially at rest. W. S.

628. *Fall Machine.* **J. J. Taudin Chabot.** (Phys. Zeitschr. 3. pp. 489–491, Aug. 1, 1902.)—A falling body has less apparent weight, as may be shown by a combination of an Atwood's machine with a balance; a body being lifted has more. As long as the increment of velocity is constant the apparent loss or gain of weight remains constant. The author has devised a rotatory mechanism for demonstrating this principle under variations of acceleration. A. D.

629. *Earth's Motion and the Ether.* **E. v. Oppolzer.** (Akad. Wiss. Wien, Sitz. Ber. 111. 2a. pp. 244–254, 1902.)—A discussion of the possible complete or partial motion of the ether along with the earth, in the course of which the work and suggestions of Doppler, Fizeau, Fresnel, Michelson, and Lorentz are dealt with. [See also Abstract No. 1512 (1902)]. E. H. B.

LIGHT.

630. *Aplanatic Refraction at Curved Surfaces.* **L. Matthiessen.** (Ann. d. Physik, 9. 3. pp. 691–702, Oct., 1902.)—Starting from Neumann's equations for the refraction of an astigmatic beam at a curved surface, the author proves, by mathematical treatment, that, when a beam, proceeding from a very distant luminous point, is refracted through a surface of rotation of the second order and passes through a focus, the refraction is aplanatic. Conversely, as Detels also proved in 1887, when the rays from very distant luminous points pass, after homocentric reflection or refraction at a surface of rotation, through a fixed point, the surface is of the second order, and the fixed point is a focus. The above theorems admit of application to the theory of refraction in the ellipsoidal cornea of the human eye, and it is concluded that this ellipsoidal form possesses extremely favourable dioptric properties for the purposes of periscopy. G. E. A.

631. *Index of Refraction of the Solid Hydrocarbons in Petroleum.* **C. F. Mabery** and **L. Shepherd.** (Amer. Acad., Proc. 38. 6. pp. 283–290, Oct., 1902.)—Employing the Pulfrich refractometer, the cup placed on the prism is surrounded by one heating coil, another coil being placed inside the liquid obtained by dissolving about 20 per cent. of the solid in a petroleum distillate with a boiling-point 202°–203° at 50 mm. The inner coil is employed to regulate the temperature of the liquid as indicated by a mercury thermometer. The values obtained for the molecular refraction, calculated from the formula for mixtures, agreed well with the theoretical values; and there is a close agreement in the hydrocarbons separated directly from petroleum, and the corresponding bodies from paraffin. G. E. A.

632. *Luminosity and the Kinetic Theory.* **J. Butler-Burke.** (Electrician, 49. pp. 910–911, Sept. 26, 1902. Abstract of a paper read before Section A of the British Association at Belfast.)—Luminosity is the result of the bombardment of large molecular aggregates by the free corpuscles in the luminous body. The effect of molecular forces is one of great importance, solids being much more phosphorescent than liquids, and liquids much more than gases. There is conclusive evidence that separate molecules exist during the process of the change of refrangibility of light, since it is found that the period of the phosphorescent light is independent of that of the exciting light, which proves that the vibrations are not forced. Other experimental facts are cited in support of the belief that separate phosphorescent molecules exist. The "pressure" glow shows that, if a discharge is sent through a gas, it is not until the length of the free path has reached a certain value that the gas begins to glow; *i.e.*, collisions of sufficient violence to excite phosphorescence do not occur until the work done by a group of molecules on a corpuscle, as it moves towards them along its free path, has reached a certain amount; in other words, it is not until a certain vacuum is reached, which is, in the case of oxygen, 0·7 mm. [See also Abstracts Nos. 366 and 2348 (1901).] G. E. A.

633. *Spectroscopic Methods.* **H. Konen.** (Ann. d. Physik, 9. 4. pp. 742-780, Nov., 1902.)—Although a very considerable amount of material is avail-

able in connection with exact measurements and general character of line spectra, the same cannot be said to be the case with band spectra; while there is no doubt as to the origin of line spectra, there is considerable doubt in connection with band spectra, this being particularly evident in the case of the carbon band spectra. In this paper are given the results of an investigation into the electric discharge under liquids with the view of more completely studying the whole phenomenon in general and band spectra in particular. Three kinds of discharge were employed—(1) the arc, (2) the brush discharge, and (3) the spark discharge with and without a condenser. For the arc discharge a continuous current was employed of 60 amperes at 72 volts, or 20 amperes at 220 volts, and the electrodes with the enclosing fluid were placed in a deep glass basin provided with a quartz window; the light passing through this window was focussed by a quartz lens upon the slit of a grating spectroscope, the grating of which had a focal length of 1 m. For the electrodes copper, iron, brass, or carbon was used, and very many liquids were experimented with; it was found that the electrodes were rapidly disintegrated except in the case of liquids containing carbon being used, when graphitic carbon was rapidly deposited upon them. This disintegration of the electrodes and the decomposition of the liquid rapidly rendered the latter muddy, so that considerable light absorption took place; this difficulty was overcome to a great extent by continually supplying fresh liquid to the arc, best by having a tube placed between the quartz window and the arc, into which the fresh liquid was passed. In every case a continuous background to the spectrum was obtained, reaching to $\lambda = 3,600$, and further, the calcium lines at $\lambda = 3,934$ and 3,969 were always seen, as were also the aluminium lines at $\lambda = 3,944$ and 3,962. The D lines of sodium were present always as absorption lines, showing that the sodium vapour in the arc enclosed in liquid has a very low temperature. Of the metallic spectra the following were examined: iron, copper, brass, also calcium, barium, sodium, potassium, lithium, and thallium, and these were all found to give bright line spectra; in no case were any banded spectra seen. The intensity of the lines was less than in the arc in air, and fewer "self-reversals" were visible; the lines were in general sharper than usual, so much so that this method is to be recommended for the study of metallic spectra. Relative intensities are in cases altered, some lines actually being invisible. The nature of the surrounding liquid has no influence upon metallic spectra; this is especially true for alcohol, pure water, glycerine, and non-conducting liquids generally, and true within limits for salt solutions. No lithium lines are visible in the case of a solution containing several per cent. of lithium chloride; with concentrated solutions of barium and calcium chloride only the strongest lines of these metals can be detected. On the other hand, the metallic spectra can be obtained by using hollow carbon electrodes filled with metallic salts. In the case of carbon electrodes the nature of the surrounding liquid has a great influence. Under ordinary circumstances the four so-called cyanogen bands are obtained, namely, the bands with heads at $\lambda = 4606{\cdot}33$, $4216{\cdot}12$, $3883{\cdot}55$, and $3590{\cdot}48$. If, however, the carbon electrodes be well heated first and then the arc be made in water previously well boiled, these bands are not to be seen, but only the "carbon" bands. A very small quantity of air blown into the water at once produces the cyanogen bands. These bands are invisible when alcohol, carbon, tetrachloride, or petroleum are used. In the last case, however, a trace of the band at $\lambda = 3883$ could be seen. Traces of the bands were seen with a solution of potassium nitrate. In fine, it was proved that the presence of nitrogen in the liquid or in the shape of dissolved air gives rise always to the cyanogen bands, and in its absence the bands are not seen. The small effect of the potassium nitrate is readily explained by the previous experiments on the small influence of dissolved salts. Evidently, therefore, the cyanogen bands have their origin in cyanogen. The author investigated the Swan spectrum, which is always visible, in the same way. Till recently this spectrum has been attributed to the element carbon, and the second banded spectrum of carbon to carbon monoxide. Stokes suggested that the former was due to carbon monoxide, and Smithells experimentally showed this to be so, and also that the second spectrum was due to carbon dioxide [see Abstract No. 1272 (1901)]. The author does not consider this view to be conclusively proved, and made a great number of experiments to find whether the presence of oxygen was necessary for the appearance of the Swan spectrum in his fluid-enclosed arc. This latter case was recently proved for the particular case of cyanogen in vacuum tubes [see Abstract No. 2347 (1901)]. Carbon electrodes were heated carefully in vacuo, and then immersed in various liquids which had been carefully dried. In all cases were the Swan bands seen. The author, however, admits that the entire absence of oxygen could not be proved. For the brush and spark discharges a large induction coil giving in air a spark of 1 m. was used finally, and the various types of discharge were examined between metal electrodes in many liquids. The brush discharge was too weak to be spectroscopically investigated, while the uncondensed spark discharge gave weak lines, and, in the case of carbon-containing liquids, the Swan bands, so that the effect of the liquid preponderated. With the condensed spark discharge the whole effect is altered. In the first place the surrounding liquid has no influence, and in the second place the spectrum of the electrodes always preponderates—very similar to the arc discharge. Dark lines were obtained amongst the bright, but in no case could all the lines be obtained reversed, as Hale claims to have done [see Abstract No. 1539 (1902)]. Hale further does not state that he used a condenser, but it is evident from these results that one must have been employed. The metallic spectra of iron, copper, and aluminium were examined in various salt solutions and in water; many differences between the spectra obtained and the ordinary spark spectra in air, which are detailed in a table appended to the paper. [The ease with which carbon absorbs oxygen from the air is probably sufficient to account for the author's failure to get rid of the Swan spectrum. The carbon rods were, it is true, heated *in vacuo*, but they were taken out of the exhausted vessel and then put into the liquid, thereby being a sufficient time in the air to absorb considerable quantities of oxygen.] E. C. C. B.

634. *Röntgen Rays and Hertzian Oscillations.* **P. Duhem.** (Comptes Rendus, 135. p. 845, Nov. 17, 1902.)—The author states the following conclusions: (1) Transversal electromagnetic waves are propagated in dielectric media according to the laws of the electromagnetic theory of light. (2) Longitudinal electromagnetic waves are propagated in all dielectric media with the same velocity, equal to the velocity of light *in vacuo*; they travel also with this same velocity in perfect conductors. Attention is called to the analogy which appears to exist between longitudinal electric oscillations and the Röntgen rays. J. J. S.

635. *Velocity of Röntgen Rays and of Light.* **R. Blondlot.** (Comptes Rendus, 135. pp. 721–724, Nov. 3, 1902.)—A further description is given of experiments comparing the velocities of Röntgen rays, Hertzian waves, and

light [see Abstract No. 426 (1903)]. Supposing *à priori* the equality of the velocities of propagation, it was foreseen that the reinforcement produced by the tube on the spark must pass through a maximum for a certain distance from the tube. This has been confirmed by experiment. Calculations were made beforehand of the displacements that the position of the tube corresponding to this maximum must experience either by the lengthening of the connecting wires or by the addition of a small line to the resonator. It should be possible to compensate the time taken by the electric waves to traverse a certain length of wire by the time that the Röntgen rays take to travel an equal distance. This compensation is actually produced, and by two methods employed the ratio of the velocities was found to be 0·97 and 0·93. The occurrence of a position of maximum brilliance of spark, its displacements, and other circumstances of the phenomena, seem only capable of explanation by supposing that the velocity of propagation of Röntgen rays is equal to that of Hertzian waves or of light in air. J. J. S.

636. *Velocity of Röntgen Rays.* **R. Blondlot.** (Comptes Rendus, 135. pp. 763–766, Nov. 10, 1902.)—As a continuation of the previous account of his work (see preceding Abstract), the author gives a description of the results of further experiments. (1) When the wires of transmission, being inserted within tubes of caoutchouc, were brought together and connected over a length of 40 cm., the velocity of propagation of the waves was diminished, since it took place principally in the caoutchouc; the position of the tube giving the maximum effect was, in fact, changed by 11 or 12 cm. (2) When a condenser with plates of 100 sq. cm., separated by a sheet of ebonite 0·8 cm. thick, was placed in a derived circuit on the line of transmission, the retardation was still greater. (3) The transmitting wires, originally 80 cm. long, having been lengthened by 57 cm. (a length greater by 4 cm. than the distance from the gap to the position of the tube which gives the maximum effect in the case of wires 80 cm. long), the spark constantly diminished when the tube was moved away. (4) When the total length of the wires was reduced to 64 cm. the spark, on the contrary, increased when the tube was moved away, starting from the position of the minimum. These experiments agree with what was foreseen. The hypothesis of Stokes and Wiechert as to the nature of the Röntgen rays accounts for all the facts known up to the present. J. J. S.

637. *Radio-active "Volatile Substance" in Uranium Blende.* **O. Behrendsen.** (Phys. Zeitschr. 3. pp. 572–573, Sept. 15, 1902.)—On heating pitch blende, especially from Joachimsthal, in a porcelain crucible, there is often found on the lid a sublimate six times as radio-active as the pitch blende. Its radiations are not the same as those of radium, but appear to correspond with those of polonium. A. D.

638. *Radio-activity of Air embedded in Rocks.* **J. Elster** and **H. Geitel.** (Phys. Zeitschr. 3. pp. 574–577, Sept. 15, 1902.)—Cave and cellar air acts as if it were itself radio-active or had become so. Air aspirated from rock-masses is specially active. Masses of air absorbed under the earth's surface must therefore be exercising an influence upon our atmosphere, ionising it, &c.

A. D.

HEAT.

639. *Expansion of Iron, Copper, Aluminium, Brass, and Bronze at High Temperatures.* **W. Dittenberger.** (Zeitschr. Vereines Deutsch. Ing. 46. pp. 1532–1536, Oct. 11, 1902. Communication from the Physikalisch-Technische Reichsanstalt.)—The expansion of these metals was examined by Holborn and Day's method [see Abstract No. 372 (1901)], and with the following results, the expansions per unit length up to T° C. being expressed as $1 + (at + bt^2)10^{-9}$.

	T.	*a*.	*b*.	
Weld iron	750	11,691	4·70	(Mean for 2 specimens)
Ingot iron	750	11,475	5·30	„ 2 „
Ingot steel	750	11,181	5·26	
Cast iron	875	9,809	5·96	„ 3 „
Copper	625	16,070	4·030	
Aluminium	610	23,536	7·071	
Brass	375	17,476	8·767	
Bronze	500	17,044	4·34	

Aluminium between 250° and 610° does not well conform to any quadratic formula, and doubtless undergoes changes of state within this range. At higher temperatures than 375° the brass (Cu 61·54, Zn 37·89, Pb 0·43) ran, and its expansion increased with the duration of the heating, but the bronze (Cu 84·06, Zn 8·69, Sn 6·25, Pb 0·71) exhibited no such behaviour up to 500°.

R. E. B.

640. *Dilatability of Quartz along its Axis.* **K. Scheel.** (Ann. d. Physik, 9. 4. pp. 837–853, Nov., 1902. Communication from the Physikalisch-Technische Reichsanstalt.)—A modification of Fizeau's method, employed in 1896 by Reimerdes, was used, the usual table being replaced by a ring of quartz 1·4582 cm. thick, and with internal and external diameters of about 3 and 4·6 cm., cut nearly perpendicularly to the axis (only 34′ off), which rested upon a plane surface of quartz blackened below, and had a quartz cover very slightly wedge-shaped (in order to throw out of the field of view the image given by its upper surface), and with a very small silver mirror on its lower surface. The piece of quartz from which the ring was cut had its surfaces slightly inclined (at about 22″) so that interference-bands might be formed without interposition of any other bodies; the upper and lower surfaces of the ring were further slightly cut away so as to leave only three small triangular parts above and below at which it would touch the cover and the base. This combination was placed in a double-walled enclosure, and warmed by the circulation between these walls of either aceton vapour (56°) or steam, the temperature of the enclosure being found by thermoelectric comparison with that of a glass tube entirely enclosing a thermometer (previously compared with a H-thermometer) and traversed by the vapour. The monochromatic light used was either the yellow Na line ($0·5790\mu$) or the Hg green line ($0·5460\mu$), and this was passed into the vessel by a right-angled totally reflecting prism. Care had to be taken to get rid of the air-cushions at the triangular points of support: this was done by preliminarily heating several times to 100°, and weighting the quartz cover with a metal ring. In the result the constants of the quadratic formula $l/l_0 = 1 + at + bt^2$ were found to have the values $a = 7{\cdot}144 \times 10^{-6}$, $b = 8{\cdot}15 \times 10^{-9}$, which very nearly agree with Benoit's determination. R. E. B.

641. *New Optical Method of Measuring Temperatures.* **D. Berthelot.** (Annal. Chim. Phys. 26. pp. 58–144, May, 1902.)—This rests on the assumption that if the density of a gas is lowered in the same ratio either by isopiestic rise of temperature or by isothermal lowering of pressure its index of refraction alters by the same amount. The method consists in breaking up a beam of light into two parts, passing one through a tube containing air and isopiestically heated to the required temperature, and the other through a tube containing air of which the pressure can be varied, receiving both beams in a telescope and varying the pressure in the second tube till the interference bands return to the position they occupied before the first tube was heated. A pair of Jamin's thick plates were employed to separate and recombine the two parts, and, in order to increase the distance between these parts to 9·2 cm. so that the experiment might be carried out, they were passed through exactly similar totally reflecting Fresnel prisms. Details of the necessary precautions to be taken and of the calculations to be made, of experiments made to test the method at the boiling-points of ethyl alcohol, water and aniline, of an electric furnace (made of a Pt spiral) for high temperature heating, and of a preliminary study of Pt — PtIr thermocouples, are given at length, as also of the experiments resulting in the following determinations (estimated to be correct within ±2°):—Boiling-points: Se 690°, Cd 778°, Zn 918°. Fusing-points: Ag 962°, Au 1064°. The variation of the b.p. for every cm. of pressure is 1° for Se, 1·11° for Cd, and 1·25 for Zn.
R. E. B.

642. *Impurities in Compressed Oxygen and their Effect on Combustion in a Calorimetric Bomb.* **Berthelot.** (Comptes Rendus, 135. pp. 821–824, Nov. 17, 1902.)—For the determination of heats of combustion by the calorimetric bomb the compressed oxygen must be pure. The presence of water-vapour is indeed beneficial, and the presence of CO_2 in small quantities does not matter, and a little N_2 (from which HNO_3 will be formed) will entail only a slight correction. But H_2 and combustible gases and vapours resulting from the preparation or compression of the oxygen (*e.g.*, at the expense of the lubricator) must be burnt up by passage of the gas through a very thick tube of red copper kept at red heat or allowance must be made for them. R. E. B.

643. *Rupture and Displacement of Equilibrium.* **Jouguet.** (Comptes Rendus, 135. pp. 778–781, Nov. 10, 1902.)—This is in continuation of a former paper [see Abstract No. 2230 (1902)], the principles enunciated in which are here applied to chemical systems subjected to (1) adiabatic variations of volume, (2) isopiestic or isometric heating. In the latter cases, if a system is heated at first sufficiently slowly for no chemical modification to occur, but for its temperature to rise, and if it is then allowed to alter adiabatically, a chemical modification ensues which lowers the temperature, the final temperature being higher than or the same as the initial temperature according as the isothermal equilibrium is stable or indifferent, the adiabatic equilibrium being stable. R. E. B.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

644. *Dynamics of Electrons.* **M. Abraham.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 1. pp. 20–41, 1902.)—In this paper the author endeavours to deduce a system of electrodynamics from the differential equations of the electromagnetic field. W. Wien has shown [see Abstract No. 765 (1901)] that in an electromagnetic system of mechanics, the masses, in place of being invariable, vary in a manner depending on the velocities of the electrons, when these approach the velocity of light. Kaufmann's experiments [see Abstract No. 457 (1903)] on the electric and magnetic deflection of Becquerel rays, have demonstrated the existence of such a variation in the mass of the electrons with the velocity. The problem considered by the author was to determine whether the mass of an electron could be entirely explained as arising from dynamical actions of its electromagnetic field, without assuming the existence of any masses independent of the electric charges. The investigations of W. B. Morton [Phil. Mag. 5. 41. p. 488, 1896] and G. F. C. Searle [Phil. Trans. 187A. pp. 675–718, 1896, and Phil. Mag. 5. 44. pp. 329–341, 1897] of the field and field energy of uniformly moving charged ellipsoids may be taken as a starting-point for the dynamical theory of electrons. Knowing the field energy, however, only suffices for the determination of the "*longitudinal masses,*" viz., those which measure the opposition to acceleration in the line of motion. To determine also the "*transverse masses,*" which affect the acceleration perpendicular to the line of motion, the author seeks to determine the electromagnetic momentum, a vector quantity, the determination of which also simplifies that of field energy and the longitudinal masses. The assumptions made in obtaining the fundamental equations are: (1) that the velocities of the electrons are considerably less than that of light; (2) that these velocities undergo no sudden changes. The field due to an electron may then be taken to be of a quasi-stationary nature, viz., it may be taken as a function of the instantaneous velocity of the electron. It will also depend, necessarily, on the form of the electron and the distribution of the charge. A vectorial equation representing the force acting on an electron in virtue of its motion is then obtained, assuming both ordinary and electromagnetic mass, the latter being a function of both the magnitude and direction of the velocity. To integrate this equation, the author makes use of two principles generalised from the corresponding well-known ones of ordinary mechanics:—(1) The increase of the sum of the mechanical and the electromagnetic energy per unit of time is equal to the work done by external forces; (2) the increase per unit of time of the vector sum of the mechanical and electromagnetic momenta is equal to the external force. Expressions are then deduced for the values of the longitudinal and transverse masses, the former agreeing with that obtained by Kaufmann. It follows from them that the electromagnetic mass is a vector quantity of the nature of a tensor, with the same kind of symmetry as an ellipsoid of rotation. The author then considers the general problem of determining the field of a uniformly moving electron of any form, carrying a charge distributed in any manner, and shows that the ponderomotive force on a unit of charge is, in a stationary field, the slope of a scalar function ϕ, which latter he calls the "*convection potential.*" He then shows that the potential function $U=\iiint dv\frac{\rho\cdot\phi}{2}$ represents the difference between the energies of the electric and magnetic fields, a result already given by Searle, and hence determines completely the values of the electromagnetic momentum and of the transverse and longitudinal electromagnetic masses. In the case of an ellipsoidal electron moving uniformly in the direction of one of its principal axes, and having either a charge distributed uniformly throughout its volume, or a uniform superficial distribution throughout the volume of a thin shell formed by two similar and similarly placed ellipsoids, the determination of the function U can be reduced, by a transformation due to Searle, to that of a system at rest, and it can therefore be evaluated. Spherical electrons are then specially considered, and the numerical results obtained are compared with Kaufmann's experimental results. The agreement is very close in the case of the kathode rays, and of the slowest Becquerel rays, on the assumption that the masses of the spherical electrons are entirely electromagnetic. The author points out that the exclusion of sudden changes of velocity renders his theory inapplicable in cases of kathode and Becquerel radiation, when there is any sensible dissipation of the energy into Röntgen radiation. G. W. DE T.

645. *Dynamics of Electrons.* **M. Abraham.** (Phys. Zeitschr. 4. 1b. pp. 57–62; Discussion, pp. 62–63, Oct. 10, 1902. Paper read before the 74 Naturforscherversammlung at Carlsbad.)—In this paper the author gives a *résumé* of the results obtained in the memoir dealt with in the preceding Abstract, and discusses the methods by which a general system of electromagnetic dynamics based on the electron theory may be developed. He observes that Lagrange's equations, Hamilton's principle of least action, and similar fundamental dynamical propositions, will only be applicable under certain restrictions, in the case of such a general electromagnetic theory. Corresponding generalised expressions may, however, be obtained, of which they are simply special cases, applicable when the velocities considered do not exceed certain limits. The dynamics of electrons is the simplest portion of a general system of electromagnetic dynamics. An electron with a movement of translation only will correspond to a material point, and a rotating electron to a rigid body in the ordinary mechanics. G. W. DE T.

646. *Magnetic Effect of Electrical Convection. II.* **H. Pender.** (Phys. Rev. 15. pp. 291–305, Nov., 1902.)—The author has repeated his previous experiments [see Abstract No. 2140 (1901)] under more favourable conditions with the object of determining whether similar results would be obtained if the speed and potential of the discs were varied. The results of the experiments were entirely consistent and confirmatory of the previous ones.

An experiment was also made to test whether, as observed by V. Crémieu [see Abstract No. 1100 (1901)], the introduction of an earthed condensing plate, between the charged rotating disc and the magnetic needle, produced any effect, but no effect was observed apart from what was due to traces of iron in the plate.

Crémieu's method was also applied to the investigation of the magnetic effect of a dielectric moving in a uniform electrostatic field, *i.e.*, of the magnetic action of a moving apparent charge. The results obtained were consistent with those arrived at by a method of calculation similar to that previously employed. W. E. T.

647. *New Theory of the Wimshurst Machine.* **F. V. Dwelshauvers-Dery.** (Deutsch. Phys. Gesell., Verh. 4. 13. pp. 276–277, Sept. 23, 1902. Paper read before the 74 Naturforscherversammlung at Carlsbad.)—At the request of de Heen the author contributed the following results: If an insulated body AB is moved rapidly towards a charged body C it becomes similarly charged (see Fig. 1). This phenomenon cannot be due to induction, since the charges at A and B are similar. If the motion is in the opposite direction so that the conductors are separated the sign of the charge in AB is reversed. These experimental results suggest the following explanation of the Wimshurst machine, in which the second plate is indicated by dotted lines and dashed letters. Suppose that there is a trace of positive charge in C (Fig. 3). The elements of the sector bOC are approaching C; hence they become positively charged, and the charge in C is increased. In the sector COd the reverse takes place, though the change is numerically less since the surface is less. The elements of the sector dOE become negatively charged since it is receding from C, hence E becomes negatively charged. A trace of electricity in either C or E thus determines the poles of the machine. In the above only one plate has been dealt with. The machine does give charges when only one plate is used, but they are so small that an electroscope is required for their detection. When both plates are used the second acts like the first, the positively charged sector b′OC increases the charge in C, and the negatively charged sector increases the charge in E. The most important action, however, is that of the one plate on the other. In the angle dOd′, for instance, the positively charged elements are approaching one another, and hence become more and more charged. This action is greatest when the distance between the plates is as small as possible. J. E.-M.

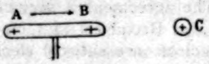

Fig. 1.

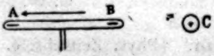

Fig. 2.

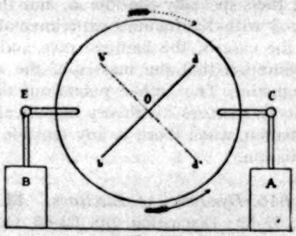

Fig. 3.

648. *Unipolar Induction.* **H. Cahen.** (Elektrotechn. Zeitschr. 23. pp. 921–926, Oct. 16, 1902.)—Referring to Hoppe's experiments on this subject [see Abstract No. 2239 (1902)], the author considers their interpretation by Hoppe unsatisfactory, and regards the experiments as inconclusive. He points out that in experiments of this nature we have to deal with three different velocities: (1) that of the magnet; (2) that of the conducting circuit; (3) that of the magnetic lines. In Hoppe's experiments the resultant induced e.m.f. in the circuit depends simply on the relative velocity of magnet and circuit, and the question as to whether the lines move with the magnet or not cannot be definitely settled by such experiments. The author then draws an analogy between the motion of a magnetic field and the motion of a solid through a viscous liquid, and suggests that the general law governing the motion is the same in both cases, viz., that the rate of dissipation of energy

is a minimum. From this law, and the fact that in the unipolar induction experiments the total e.m.f. is independent of the velocity of the field (depending simply on relative motion of magnet and conductor), it follows immediately that the magnet carries its field round with it. The author next applies the same law to the elucidation of another problem—that of an ironless dynamo—and shows the impossibility of constructing such a machine.

A. H.

DISCHARGE AND OSCILLATIONS.

649. *High-Voltage Arcs.* **B. Monasch.** (Elektrotechn. Zeitschr. 23. pp. 956–958, Oct. 30, 1902.)—With currents varying from 0·02 to 0·068 ampere, electrodes of lead, bismuth, and antimony are too easily volatilised to be of use. Practically all other substances can be used, and the author conducted his experiments with copper electrodes. After an arc of 0·068 ampere had passed for three hours between copper electrodes, 5 mm. in diameter, the change in the diameter was certainly less than 0·01 mm., and the surface was covered with a slight black film. Alternate current of 47 cycles was used, and the power consumed in the arc was measured by the electrostatic wattmeter described by Blondlot and Curie in the Journal de Physique, p. 80, 1889. In order to keep the conditions constant during the tests, the electrodes and their supports were placed on the receiver of an air pump and covered with a glass bell jar, having a volume of 0·003 cub. m., into which air could be drawn through wash-bottles, filled with sulphuric acid. Under these conditions, steady readings could be obtained within three minutes of starting the arc. A bell jar is necessary, otherwise the mere movements of the observer cause draughts, which make the arc unsteady. The author first examined the relation between the length of arc, and watts consumed, both real and apparent, the current being maintained constant. This relation is graphically expressed by a straight line in all the cases examined. Calling the ratio of real watts to volt-amperes the apparent lag or the power-factor, with a current of 0·041 ampere the power-factor rises from a value of 0·58 with an arc 3 mm. long, to 0·63 with an arc of 10 mm., the copper electrodes having a diameter of 5 mm. The real watts in this case varied from 17 to 29. The next point investigated was the effect of the atmospheric pressure within the bell jar on the arc, and more particularly the effect produced by a partial vacuum. Although the pressure required to maintain a given arc in a vacuum is rather higher than that required at ordinary atmospheric pressure, the voltage does not pass steadily from the one value to the other, but falls and passes through a critical point. The author's investigations extended to a pressure of one-seventh of an atmosphere, below which point he was unable to get steady readings. Over this range he found that the voltage required to maintain an arc of given length decreased steadily. With arcs of from 8 to 8·7 mm., the voltage required with a mercury pressure of 100 mm. is about 40 or 50 per cent. less than that required under ordinary atmospheric pressure. Three diagrams are given in the article. The first shows the relation of real and apparent watts to length of arc, the current being maintained constant; the second shows the relation between the voltage and the mercury pressure under partial vacuum for various lengths of the arc; and the third shows similarly the relation between real and apparent watts and the mercury pressure under the same conditions.

W. H. S.

650. *Electrical Conductivity of Flames.* **P. Lenard.** (Ann. d. Physik, 9. 3. pp. 642–650, Oct., 1902.)—Various simple experiments are described which show the presence of ions, generally positive, in flames. On opposite sides of a flame, which may be a Bunsen, blow-pipe, or oxyhydrogen, electrodes are placed and are charged to a strong difference of potential, either by a battery or influence machine. If a platinum spoon containing various salts is now carefully brought into the flame, the part coloured by the presence of the salt vapour does not rise vertically, but goes across to the negatively charged electrode. The behaviour of different salts is investigated. The velocity of the positive ions is measured and is found to be one thousand times smaller than that obtained by H. A. Wilson. The author gives reasons for thinking that the negative ions are purely negative charges of electricity separated from ponderable matter. [See also Abstract No. 1722 (1899).] R. S. W.

651. *Luminous Electric Wind.* **E. Warburg.** (Phys. Zeitschr. 4. 1b. p. 40, with Discussion, Oct. 10, 1902. Paper read before the 74 Naturforscherversammlung at Carlsbad.)—By the point discharge in air and other gases of atmospheric pressure, the luminous effect at the negative terminal shrinks to a mere point or star. But in nitrogen quite freed from oxygen and on using a great enough current, a fine luminous pencil may be observed extending from the star. E. H. B.

652. *Positive Electrons.* **W. Wien.** (Ann. d. Physik, 9. 3. pp. 660–664, Oct., 1902.)—By the method of simultaneous deflections magnetically and electrostatically the value of the ratio, charge to mass, of an ion is examined. It is found that this ratio (here called specific charge) for a positive ion has a continuously variable value and attains a maximum of the order 10,000, in agreement with that found by electrolysis for hydrogen. To harmonise with some of the experimental results here obtained, it is suggested that the negative electrons possess only a small part of the charge of an ion. Then, by the admission of different numbers of negative electrons, molecules might have different specific charges. [See also Abstract No. 466 (1903).]

E. H. B.

653. *Electric Discharge by Ultra-violet Light.* **T. Wulf.** (Ann. d. Physik, 9. 4. pp. 946–963, Nov., 1902.)—The author seeks to establish the relationship between the extent to which a negatively charged conductor is discharged by ultra-violet light, and the (electro-chemical) e.m.f. between the conductor and the gaseous medium in contact with it, through which the ultra-violet light effects the discharge. For these experiments it is necessary to have a very constant source of light. A Nernst lamp was therefore tried; but it was found to be too poor in ultra-violet rays for the purpose. The electric arc, whether with cored or solid carbons, was insufficiently constant in intensity to yield trustworthy results. A lamp of the Sell type was therefore designed, in which CS_2 is burnt in oxygen; it was improved with a view to security against explosions. Most of the experiments, however, were carried out with an arc lamp. The electrode, upon which the light falls, is contained in a spherical glass vessel 7 cm. diameter, into which gases can be passed through two tubulures in the sides. An opening at the top of the vessel can be closed by a quartz disc of 2 mm. thickness. The electrode is supported by a vertical metal rod passing through an indiarubber stopper which closes a third tubulure at the bottom of the vessel. The indiarubber stopper is surrounded, except at the top and bottom, with tin-foil, connected

to earth. The rod is connected to the needle of a quadrant-electrometer, the quadrants of which are permanently charged from two or three cells. Above, and parallel to, the electrode is placed, within the vessel, a flat spiral of platinum wire. Connection with this appears to have been made by means of a platinum wire sealed into the side of the vessel. The spiral is connected to the electric supply mains at + 220 volts. Any negative electricity discharged by exposing the electrode to ultra-violet light thus gives a positive charge to the needle of the electrometer connected with it. The tin-foil ensures that the effect of leakage from the spiral shall be to diminish and not to increase the deflection of the electrometer. In the first experiment recorded in the paper, a platinum plate is first surcharged with oxygen in an electrolytic cell, its potential in the cell being compared with that of zinc in zincic-sulphate. The platinum is then quickly removed from the cell and dried. Immediately afterwards, it is placed in the spherical vessel as the active electrode. This is repeated, surcharging the platinum with hydrogen. [Compare Faraday's "Experimental Researches," vol. i., § 564 *et seq.*] The electrode thus treated with hydrogen is found to be far more active in regard to the discharge of ultra-violet light than when treated with oxygen. The various potential differences observed are tabulated. In a second experiment, a platinum plate which initially brought about, when exposed in the apparatus to ultra-violet light, a deflection of 124 divisions on the electrometer-scale, increased this deflection to 636 when hydrogen was admitted and allowed to "soak in" for six hours. Air was then admitted and allowed to become quiescent; the deflection fell gradually to about 300 in 16 hours. Air was next passed through the spherical vessel as a stream; the deflection increased to about 470. But when the air was allowed to become quiescent, the deflection fell to 112. When chlorine gas was admitted, the deflection became 48; replacing this for six hours with hydrogen, it increased to 123. With newly polished platinum as the electrode, the corresponding deflections were: Chlorine, 161; hydrogen, 580. Similar results were obtained with oxygen, and also with ozone, the order of their discharging power, with platinum, for negative electricity in ultra-violet light being: Hydrogen, oxygen, chlorine, ozone, *i.e.*, the order of the positivity of those gases. The pressure appears to have been, throughout, that of the atmosphere. In the case of ozone, dampness exhibited a very decided effect in accelerating the change of activity. So also did dampness when silver plates were examined in chlorine. Experiments with electrodes of platinum, zinc, and silver respectively, lead the author to conclude that the discharging power is greater as the (electro-chemical) difference of potential between the electrode and the medium in contact with it is greater. [With regard to the paper as a whole, the results should perhaps be accepted as qualitative rather than quantitative, for it is clear that, notwithstanding the precautions taken by the author, there was doubt as to the constancy of the source of light. No photometric tests are recorded, but the electrometer readings indicate uncertainties. Electrical leakage—which might possibly have been prevented by special devices—and convection currents, especially in the case of air-streams, probably account for other variations.] Moreover, as the author points out, traces of moisture in the gases entirely alter the character of the slope of discharge. R. A.

654. *Chemical Action of Canal Rays.* **G. C. Schmidt.** (Ann. d. Physik, 9. 3. pp. 703–711, Oct., 1902.)—The results of this research are as follows: (1) The solid solutions which become luminescent under the action of kathode rays, also become luminescent under the action of canal rays. The intensity of the luminescence diminishes rapidly on account of the changes which take place in the solutions. (2) While in the spectrum of the kathode-luminescence a colour is always present to some degree, in the spectrum of the canal-luminescence a colour is only present in the moment or so. After a very short time the fluorescence is white, all the spectral colours being present. (3) Canal rays always have a dissociating action, dissociating the substance they impinge on as well as the gas they pass through. (4) If an oxidisable body is placed in an atmosphere of oxygen then the canal rays produce an oxidising action. (5) If a reducible compound is placed in an atmosphere of hydrogen, then the canal rays produce a reducing action. (6) The most typical reaction of canal rays is that discovered by Arnold of the splitting up of the sodium salts, making the D line clearly visible in the spectrum. J. B. H.

655. *Screening from Electric Waves by Gases.* **E. Lecher.** (Phys. Zeitschr. 4. 1b. pp. 32–38; Discussion, pp. 38–39, Oct. 10, 1902. Paper read before the 74 Naturforscherversammlung at Carlsbad.)—An induced current is produced from a primary alternating current, an annular space filled with the gas under test intervening between the primary and secondary. The following results are specially noteworthy: (1) The absorption at 760 mm. pressure appears slightly greater than with vacuum or with 1 mm. pressure; (2) the absorption is a minimum at about 1 mm. pressure, and attains a maximum of many times that value at about 0·1 mm. pressure or less, and falls off to zero for absolute vacuum. E. H. B.

656. *Wave Propagation over Non-uniform Conductors.* **M. I. Pupin.** (Elect. World and Engineer, 39. pp. 384–387, March 1, 1902.)—The author here continues his treatment of conductors for telephones and other purposes where electric waves are used, showing the kind of approximation obtainable when the leakages, resistances, and inductances are inserted at intervals and not uniformly distributed as is theoretically desirable to eliminate distortion. [See Abstract No. 328 (1902).] The results may be thus summarised: A non-uniform wave conductor is one made up of periodically recurring sets of preferably equal parts, which may be called its component parts. Each component part has definite reaction constants, that is, definite resistance, capacity, and leakage conductance, and corresponds, therefore, to a definite part on the corresponding uniform conductor. For the non-uniform conductor to act very nearly like the uniform one the length on the uniform conductor corresponding to two of these component parts must be small in comparison to the wave-length. One-sixteenth of the wave-length is a close approximation. One-quarter of a wave-length gives a much worse approximation. Provided all these component parts or sections are short enough, it does not matter how the reaction constants are distributed within any one section; they may be lumped or uniformly distributed [see also Abstract No. 328 (1902).] E. H. B.

657. *Electric Force and Energy Flux near Conductors of Electric Waves.* **W. B. Morton.** (Phil. Mag. 4. pp. 302–314, Sept., 1902.)—In the case of electromagnetic waves guided by imperfectly conducting leads, the flow of energy, as defined by the Poynting vector, is usually stated to be nearly parallel to the conductor, but converging slowly upon it. This means that the lines of electric force must leave the conductor with a slight forward tilt.

Now, an examination of the periodic vectors, as worked out by J. J. Thomson, Sommerfeld, and Mie, shows that there is a phase-difference between the radial and longitudinal components of the electric force, resulting in a backward tilt, which means that the energy-flow is either onward and outward, or backward and inward, according to the direction of the magnetic force. To examine further into these eddies of the energy-flow, the author works out in detail the case of two similar parallel wires. He uses the first approximation to Mie's complete solution, which he has shown [See Abstracts Nos. 516 and 1688 (1901)] to be simply derivable from the single-wire solution, and readily applicable to more complicated cases. The principal results arrived at are as follows: The state of affairs in the wire is governed, as is well known, by the magnitude of the quantity $a\sqrt{(\mu p/\rho)}$, where a is the radius of the wire, μ and ρ are the permeability and resistivity respectively, and $p/2\pi$ is the frequency. When this is large the skin-effect is well developed. Suppose, for simplicity, that ρ alone is altered. Then, starting with the limiting case of a very great conductivity and very thin skin, we find the region of eddy amounts to a quarter of each half wave-length, or say 45° in the argument of the periodic vectors. Further, as we should expect from the smallness of the dissipation of energy, the flow is outward in the eddy and onward everywhere. As the resistance of the wire is increased, the extent of the eddy-region at first diminishes, reaches a minimum, and then increases again. In a case which the author has worked out numerically, the minimum is 18°. As the resistance of the wire becomes very great, the length of the eddy again approaches the limiting value of 45°, but the flow is now everywhere inward; it is backward in the eddy, forward elsewhere. The author, in the course of the investigation, has obtained the equations to the lines of force, and of the Poynting flux in the plane of the wires, both inside and out. G. W. de T.

658. *Mechanical Illustration of Braun's Wireless Telegraphy.* **M. Wien.** (Phys. Zeitschr. 4. 1b. pp. 76–77; Discussion, pp. 77–78, Oct. 10, 1902. Paper read before the 74 Naturforscherversammlung at Carlsbad.)—A heavy pendulum is hung in air from a stretched wire, from which is also suspended a smaller pendulum of same length with its bob swinging in water or oil. The heavy pendulum represents the primary system with but little damping, and the smaller pendulum represents the receiver with more damping.

E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

659. *Substitution Method of Treating Problems Regarding Networks of Conductors.* **L. Monath.** (Zeitschr. Elektrotechn., Wien, 20. pp. 537–540, Nov. 2; 549–553, Nov. 9; and pp. 561–564, Nov. 16, 1902.)—The author explains the application of Kennelly's "substitution method" [see Abstract No. 156 (1900)] to the calculation of the distribution of currents in a network of conductors, and compares this method with the older one of directly solving a system of linear equations. He arrives at the conclusion that the older method is, on the whole, preferable, the substitution method offering advantages only in the special case of a network having a large number of knots and very few feeding-points. A. H.

660. *Electrical Conductivity of Metals and their Vapours.* **R. J. Strutt.** (Phil. Mag. 4. pp. 596–605, Nov., 1902.)—The author describes experiments on

mercury and arsenic, heated in sealed quartz tubes to try and determine if the remarkable change that must take place in the electrical properties as the critical temperature (at which the liquid and saturated vapour states are indistinguishable) is approached, could be observed. Attempts made by the author to predict the critical temperature of mercury by the temperature coefficient of the surface-tension, by the absolute boiling-point, and by the critical density, lead to results altogether inconsistent with one another. Attempts to observe the critical phenomena of mercury and arsenic in sealed quartz tubes failed. In both cases experiment proves that the critical temperature lies above a dull yellow heat. Up to a full red heat the conductivity of saturated mercury vapour remains of a quite different order of magnitude from that of the liquid, the latter being 10^7 times as great as the former. But, on the other hand, the conductivity of the saturated vapour is immensely greater than that of the vapour at atmospheric pressure; the former having a resistance 10^7 times that of the liquid, while the latter has one of more than 4×10^{14} that of the liquid. Thus the vapour at atmospheric pressure has a resistance of about 4×10^7 times that of the saturated vapour, both at full red heat. It need scarcely be said that this ratio is of quite a different order from the ratio of the densities of these vapours. It seems likely that as the critical temperature is approached the vapour begins to conduct freely, while the liquid changes its electrical character to a much less extent. The conductivity of saturated arsenic vapour at a bright red heat is of the same order as that of mercury, and obeys Ohm's law, at all events up to an electromotive intensity of more than 100 volts per centimetre. E. C. R.

661. *Measurement of Conductivity of Gases.* **F. Harms.** (Phys. Zeitschr. 4. pp. 11–15, Oct. 1, 1902.)—In the investigations of the conductivity of ordinary air by H. Geitel and by C. T. R. Wilson, a certain amount of uncertainty is introduced in the determination of the capacity of the electroscope. In the present method this uncertainty is avoided. The method consists in determining the rate of discharge from a body suspended in air, and the potential measuring apparatus is only connected with the body at the instant of measuring the potential. The charged body is a brass sphere suspended on a glass thread, it is charged to a certain potential by means of a battery, and after a certain time has elapsed, it is connected to the electrometer and its potential is measured. It is again charged to the original potential, and after a different interval of time its potential is again measured, and so on, each experiment giving one point on the curve of discharge. The experiments give the number of ions used and regenerated per second, and c.c. in air at 18° C. as 28, while C. T. R. Wilson's experiments gave from 14 to 19 at 15°. J. B. H.

662. *Electric Resistances.* **E. van Aubel.** (Comptes Rendus, 135. pp. 456–457, Sept. 15, 1902.)—The electric resistivity of sulphur pyrites is 1·513 ohm-cm. at 20° C., and it increases with decreasing temperature, (dR/dT) increasing as absolute zero is approached; but, in liquid air, pyrites is still a conductor, its resistance having only increased in the ratio 74·20 at —181° to 10·96 at 20°. A. D.

663. *Electrical Resistance of PbS at very Low Temperatures.* **E. van Aubel.** (Comptes Rendus, 135. pp. 734–736, Nov. 3, 1902.)—Melted PbS was poured into a mould, and the rod thus formed was carefully filed and worked till it was cylindrical and of 0·59 cm. diameter [and of length 4·45 cm.]. Its ends were tipped with tin-foil and fitted with brass terminals. Its electrical resistance was then measured by Lord Kelvin's method, and was found, like that of metals, to decrease continuously as the temperature was lowered, the experimental range being from 81·85° C. to −187·2° C., and the resistivity decreasing in this range from 361 to 66 microhm-centimetre. No minimum at any temperature was indicated. R. E. B.

664. *E.M.F. of a Thermo-element.* **H. Pellat.** (Comptes Rendus, 135. p. 733, Nov. 3, 1902.)—In Ponsot's note [see Abstract No. 568 (1903)] it is wrongly stated that Pellat's method of measuring absolute temperatures by measures of the heat absorbed at a thermo-electric junction requires a knowledge of *two* absolute temperatures: it really gives the ratio of any two absolute temperatures, so that the knowledge of *one* temperature in absolute value is sufficient to fix the whole scale. R. E. B.

665. *A Sensitive Aluminium Leaf Electrometer.* **E. Grimsehl.** (Phys. Zeitschr. 3. pp. 569–572, Sept. 15, 1902.)—The instrument described was constructed by the firm of Krüss, of Hamburg, according to the author's designs. The rectangular case is made of brass of dimensions 5 × 7 × 16 cm., and supported on three levelling screws. The back and front of the electrometer is furnished with glass plates sliding in grooves on the framework. Through an insulated ebonite stopper passes a vertical brass support for the three aluminium sheets. A piece of aluminium-foil, 90 × 3 mm., acts as the needle, and is supported between two thin sheets of aluminium 90 × 6 mm., of which one is fixed vertically and divides the charge with the needle, while the other turns on an insulated hinge from the same support and is earth-connected. This movable sheet of aluminium may be adjusted from the outside of the case until it is near the fixed sheet, and thereby increases the sensitiveness of the instrument. A graduated mica scale, reading from 0° to 30°, serves to indicate the quantitative measurements, and the author claims that the instrument will show a difference of 2 volts when the movable and fixed aluminium are 4° apart. When the distance is increased to 30°, each degree represents 10 volts. When not in use the needle is held lightly pressed between the two outer aluminium sheets. A condenser is fitted to the top of the electrometer in order to demonstrate the fundamental ideas of contact electricity. The instrument would be useful for experimenting with Becquerel rays or with ultra-violet light. E. S. A. R.

ALTERNATING CURRENTS AND MAGNETISM.

666. *Hall Effect and Thermo-electric Power.* **E. van Aubel.** (Comptes Rendus, 135. pp. 786–788, Nov. 10, 1902.)—This is an experimental investigation upon the theory of Ettinghausen and Nernst, that the Hall effect is connected with the thermo-electric power. The effect was studied for bismuth, for an alloy of antimony and bismuth, and for a mixture of bismuth and sulphate of bismuth. The results show that the Hall effect is most intense for the last, and is thrice that for pure bismuth. For the alloy it is double that for the pure metal. The conclusions of Ettinghausen and Nernst are confirmed. Further results are promised. J. W. P.

667. *Crystalline Bismuth in a Magnetic Field.* **L. Lownds.** (Ann. d. Physik, 9. 3. pp. 677–690, Oct., 1902.)—Further observations were made upon

the plate cut from a large crystal of bismuth already used in previous experiments [see Abstract No. 2158 (1901)]. Measurements were obtained of the change of electrical resistance in magnetic fields of various strength and also of the Hall effect. The determinations were made at the temperatures of 15° C., —79° C., and —186° C., a mixture of ether and solid carbonic acid, and (for the lowest temperature) liquid air being used. The results are given in tables and a set of curves. The ratio of the values of the conductivity for heat perpendicular and parallel to the principal axis of the crystal was determined—(1) with no magnetic field, (2) in a magnetic field of 4,980 c.g.s. units, though exact measurements were difficult owing to the small size of the plate of bismuth used. The ratios found were: without magnetic field, 1·42; in field of 4,980 c.g.s., 1·80. The corresponding ratios for the electrical conductivity under the same circumstances being 1·78 and 1·87. [See also Abstract No. 89 (1902).] J. J. S.

668. *Rigidity and Magnetisation.* **K. Honda, S. Shimizu,** and **S. Kusakabe.** (Phil. Mag. 4. pp. 537–546, Nov., 1902.)—Specimens of soft iron, steel, wolfram steel, nickel, and cobalt are tested. A specimen is placed horizontally in a magnetising coil and a couple is applied producing a twist which can be measured to the small amount of about $\frac{1}{500}$ of one second per cm. of the specimen. Next the magnetising field is put on and the change in twist recorded. Curves are given showing the general law that the untwisting of a rod increases with magnetisation but approaches finally an asymptotic limit. Nickel behaves in an extraordinary way, the change in torsion by magnetisation alters its sign as the magnetising force increases. This conduct is in keeping with the behaviour of this metal as regards variation in Young's modulus due to magnetisation. [See also Abstract No. 486 (1903).] P. E. S.

669. *Anomaly in the Horizontal Magnetic Component on the Puy-de-Dome.* **P. David.** (Écl. Électr. 33. pp. 188–190, Nov. 8, 1902.)—The rapid method employed in the measurements was suggested by Brunhes. Under the needle of a sine galvanometer a bar magnet is placed on the 0–180° line of the division, and the instrument turned until the needle assumes the position 90–270°. The bar magnet is now removed, and the height of the support so adjusted that the deviation α of the needle from 270° is as near as possible 45°. If K be the magnetic force on the pole of the needle, then $H \sin \alpha = K$, α being $45° \pm \gamma$; a simple formula is deduced. H. B.

REFERENCES.

670. *The Induction Coil.* **J. E. Ives.** (Phys. Rev. 14. pp. 280–314, May–June; 15. pp. 7–19, July, 1902.)—These papers give a good *résumé* of recent work, with very complete references to the originals. G. W. de T.

671. *Theory of Induction Coils.* **H. Armagnat.** (Écl. Électr. 33. pp. 217–227, Nov. 15, 1902.)—This is a summary of recent investigations. G. W. de T.

672. *The Hertz Resonator.* **A. Turpain.** (Travaux du Congrès International de Physique, 4. pp. 109–116, 1900–1901.)—This is an experimental investigation into the nature of the waves produced by different types of resonators. G. W. de T.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

673. *Significance of Changing Atomic Volume. III. The Relation of Changing Heat Capacity to Change of Free Energy, Heat of Reaction, Change of Volume, and Chemical Affinity.* **T. W. Richards.** (Amer. Acad., Proc. 38. 7. pp. 293–317, Oct., 1902.)—For Parts I. and II. of this thesis see Abstracts Nos. 2480 (1901) and 1572 (1902). In the present paper the author examines ten separate cells of the Daniell type containing copper, nickel, iron, zinc, and magnesium, in solutions of their sulphates of the strength MSO_4 200 H_2O, and proves that the loss of heat capacity during the reaction is so closely parallel to the excess of heat evolved that one is forced to infer a fundamental connection between them. These cells are selected because the extent of ionisation and the migration velocities are similar, the anion identical, and the electromotive force and heat of reaction well known. In the case of nitrate and chloride anions, and with other metals, where the figures are known, a similar rule is observed, as well as with more complicated cells in which the osmotic tendencies are nearly balanced. Aluminium alone is anomalous, but its electromotive energy is not yet settled. In a second section the same reasoning is extended to systems involving appreciable concentration effect, and the general conclusions are expressed as follows:—(1) In a reaction from which concentration effects have been eliminated, where the total heat capacity remains constant during the reaction, the change of free energy and the heat evolved are equal. (2) and (3) When the heat capacity of such a system *diminishes* during a reaction the heat evolved is greater, when the heat capacity *increases* the heat evolved is less, than the change of free energy. (4) If in addition there is unbalanced osmotic or gas pressure, this pressure adds its share of work algebraically to the change of free energy, according to the equations—

$$A = RT ln \frac{c_0^{n_0} \cdots}{c^n \ldots} + C - P = RT ln \frac{c_0^{n_0} \cdots}{c^n \ldots} + U - f(\Delta K).[1]$$

(5) Thus in a complex cell containing precipitates the change of free energy, which represents the tendency of the reaction to take place, is by no means a measure of the attractive energy concerned, but has superposed upon this attraction at least two other modifying circumstances. (6) The fact that in many reactions the change of heat capacity is small and the concentration effect about balanced, affords an explanation of the frequent fulfilment of Berthelot's approximate "rule of maximum work." (7) A distinction is drawn between endothermic and pseudo-endothermic reactions. (8) If the change of total energy could be corrected for the heat energy displaced by change of heat capacity, a measure of the total affinities might be obtained, for into this heat the osmotic tendencies do not enter. (9) If the same contraction in volume as that exhibited on combining could be produced on the uncombined factors in the reaction by outside pressure under similar conditions, the work expended might serve as another measure of the total affinity. (10) In the

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[1] A = electromotive energy, U heat evolved, *n* number of equivalents, C the sum of the chemical affinities, P the work required to change the heat capacity, c_0 the initial, and c the final, concentration.

absence of concentration-effect, the "attracting energy" of a given reaction probably lies between the change of free energy and the change of total energy. (11) It is shown that the hypothesis of compressible atoms affords a conceivable explanation of these facts, and that it is not inconsistent with either of the two laws of energy. S. R.

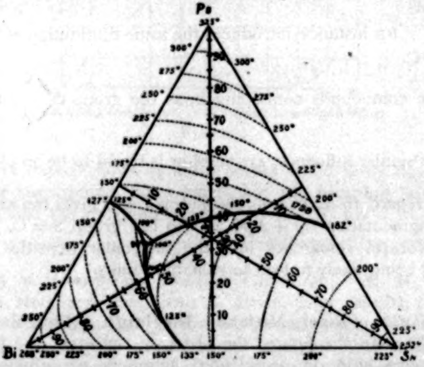
674. *Gutta-percha.* **W. Ramsay, Miss H. Chick, and F. Collingridge.** (Soc. Chem. Ind., Journ. 21. pp. 1367–1372; Discussion, pp. 1372–1373, Nov. 29, 1902. Paper read before the International Congress of Applied Chemistry.)—Payen believed crude gutta to consist of three parts, one free from oxygen "gutta," another crystalline, to which he gave the name "albane," a third non-crystalline, "fluavile." Fluavile is a yellow resin, heavier than water, hard and brittle. It softens about 58°. Its composition is $C_{20}H_{32}O$. Albane is white, heavier than water, hard and brittle, and melts at 160°. When dried at 130° it gives figures corresponding to the formula $C_{20}H_{30}O$. The formula of gutta has always been taken as C_5H_8. Caoutchouc and gutta yield the same product on distillation. The action of bromine on gutta gave either $C_{10}H_{16}Br_4$, or $C_{17}H_{27}Br_7$. The action of hydriodic acid on gutta gave $C_{27}H_{46}$, a mixture of three parts of nitric with one of sulphuric acid acts violently on gutta. If the mixture be kept cool, and the gutta added very gradually, the reaction can be made to take place without charring. Leaf gutta treated in this manner and filtered gave, on pouring the filtrate into water, a yellowish precipitate which showed acid properties. A suggested formula is $C_{18}H_{27}(NO_2)_3(COOH)_3OH$; oxidation of gutta promised better results. Gutta when dissolved in ether is particularly prone to oxidation by the atmosphere. Some gutta free from resin was dissolved in boiling ether, and left exposed to the atmosphere for two days. This residue, after evaporation of the ether, was found to be completely soluble in alcohol and in acetone; now, as gutta is wholly insoluble, it follows that complete oxidation has taken place. Its analysis shows it to have nearly the same percentage composition as albane ($C_{17}H_{26}O$). When oxidation takes place in toluene the products are different: analysis gave $C_{19}H_{32}O_4$. *Albane.*—Attempts to extract the "albane" of Oudemans and Payen, $C_{10}H_{16}O$. From gutta a resin of this composition does not yield. The action of phosphoric chloride on albane gave $C_{40}H_{63}O_3Cl$—a substance which would repay further investigation. Oxidation of albane by chromic acid was studied both in glacial acetic acid and in chloroform solution. The products differ in each case. (1) *Acetic Acid Solution:* (*a*) One atom of oxygen to one molecule of albane; (*b*) Two atoms of oxygen to one molecule of albane; (*c*) Three atoms of oxygen to one molecule of albane; (*d*) and (*e*) Four atoms of oxygen to one molecule of albane. When oxidation was carried out in chloroform solution the formation of acetic acid was detected, and in several cases aldehyde also; moreover, carbon dioxide was continuously evolved during the reaction. M. O'G.

675. *Alloys of Copper and Magnesium.* **O. Boudouard.** (Comptes Rendus, 135. pp. 794–796, Nov. 10, 1902.)—The author has determined the freezing-point curve for mixtures of copper and magnesium, and finds that on plotting the curve with the temperatures as ordinates and the proportions by weight of copper as abscissæ, three maxima are obtained at 550°, 585°, and 915°, corresponding to the compounds $CuMg_2$, $CuMg$, and Cu_2Mg; and four minima are obtained at 475°, 540°, 575°, and 890°. Alloys containing less than 70 per cent. of copper retain the white colour of magnesium; after this they become yellow. The alloy of magnesium with 10 per cent. of copper is

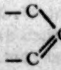
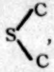
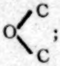
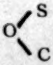
malleable; but above this the alloy becomes more and more brittle, until with 70 per cent. of copper the alloy can be crushed between the fingers. The brittleness then diminishes as the amount of copper increases; the alloy containing 90 per cent. of copper can, however, be broken with a hammer.

A. F.

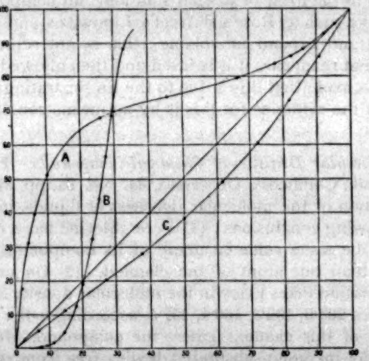
676. *Alloys of Lead, Tin, and Bismuth.* **E. S. Shepherd.** (Journ. Phys. Chem. 6. pp. 519–553, Nov., 1902.)—The freezing-points of these alloys has been studied by Charpy, whose triangular diagram is here reproduced [see Abstract No. 1070 (1898)]. Analyses of the solid that separates from the melt show that tin crystallises out in a pure state, but that bismuth separating from the alloy contains up to 4 per cent. of lead, whilst lead contains up to 5 per cent. of bismuth in the form of a solid solution; no compounds are formed. The ternary alloys, such as Rose's, d'Arcet's, Lipowitz's, and Wood's, recalesce after solidifying and expand in volume; this is not reproduced when the solid is heated, but reappears if it is fused and then allowed to solidify again. The suggestion is made that this is due to the tin separating at first in a labile denser form, but the evidence for this is by no means conclusive. T. M. L.



677. *True Molecular Densities of Chemical Compounds.* **I. Kanonnikoff.** (Jurn. Russk. Fisik. Chimičesk. Obščestva, 34. No. 6a. pp. 575–606, 1902.)—A careful investigation of the molecular densities of liquids, including chlorine, leads to the following conclusions: (1) Free chlorine has a molecular density of 219, and has the same value in many of its compounds, especially those including more than one atom of the element. (2) On uniting with other elements, a diminution takes place in the molecular density of chlorine, which assumes the values 203·9, 192·3, 169·1, 157·5, according to the conditions under which the atom of this element enters the compound. In gaseous hydrocarbons it is 157·5; in mono-substituted bodies, free from oxygen, 169·1, and in those which contain two or more atoms of it 192·3, 203·9, or 219·0, according to the quantity of chlorine. In substances containing oxygen it is, as a rule, 192·3 in the case of one atom of chlorine being present, and 203·9 or 219·0 if there are several of them. (3) Occurring in series with a carbon atom, united by a double connection to another similar one, the chlorine

atom does not disturb the double connection, being tetratomic, nor does it alter the magnitude of its molecular density; the group  always gives to Cl a molecular density = 169·1. This property of chlorine, however, does not apply to the double connection of two carbon atoms, distant from it more than one carbon atom, the double connection being dissolved in this case. Studying next the behaviour of compounds containing sulphur, the author arrives at the following conclusions: (1) Free sulphur has a molecular density MD = 121·2, and the value is the same in any compound where the sulphur acts as a bi-atomic element. In the case of its changing its atomic value, the molecular density will increase by 23·2, S^{IV} being = 144·4, and S^{VI} = 167·6. (2) In its compounds, sulphur behaves very much like oxygen; the group , for instance, introduces the same diminution of the molecular density in the compounds containing it, as the group ; and the group  exerts a similar influence, *i.e.*, sulphur is found to be an electro-positive element with regard to oxygen, as the group C = S gives the same as C = O, namely, an augmentation by + 4·84, as also the group S = O. The author, therefore, advocates researches into the molecular densities of chemical compounds as being likely to lead to valuable results. A. G.

678. *Distillation of Binary Mixtures.* **Rayleigh.** (Phil. Mag. 4. pp. 521–537, Nov., 1902.)—In the figures the abscissæ represent the percentage of alcohol, hydrogen chloride, acetic acid, ammonia, or sulphuric acid in a boiling aqueous solution, and the ordinates give the percentage contained in the vapour. The crossing of the diagonal in the hydrogen chloride curve indicates that the liquid and vapour have the same composition, giving a

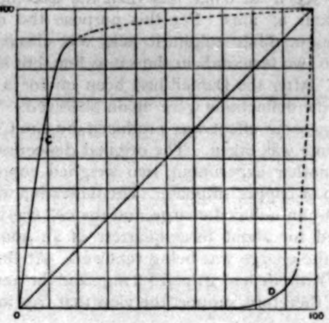


A. Alcohol and Water. B. Hydrochloric Acid and Water. C. Acetic Acid and Water.

FIG. 1.

constant-boiling mixture. A new apparatus with uniform *régime* is described in which a mixture of alcohol and water is fed into a tube connected below to a spiral maintained at 100°, and above to a spiral maintained at 77°. A continual stream of vapour flows upwards whilst liquid flows downwards; an interchange of constituents takes place, and the escaping liquid is nearly pure water, whilst the escaping vapour contains 90 per cent. of alcohol.

T. M. L.



C. Ammonia and Water. D. Sulphuric Acid and Water.

FIG. 2.

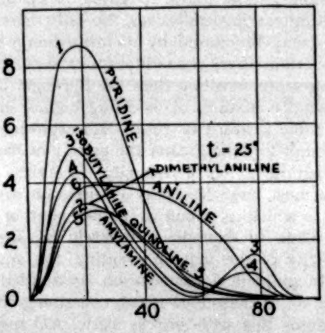
679. *Theory of Misfires, and Practical Conclusions.* **E. H. Weiskopf.** (Chemical and Metallurg. Soc. Journ. S. Africa, 3. pp. 98–101, Nov., 1902.)—Mainly refers to nitroglycerine explosives, the only ones used at present on the Rand. Misfires may be caused by an insufficiency of either ingredient in a mixture, or by certain physical conditions of the material. Nitroglycerine explosives are much more sensitive than the Sprengel class, which are very stable, and are generally mixtures of oxidising bodies, such as nitrates, with inert organic matter like sawdust or resin. An explosive will decompose the more readily and completely the greater the energy of the detonating primer. For Kieselguhr dynamite a No. 3 detonator is always strong enough, but Sprengel explosives must have No. 6 as a minimum, and frequently No. 8. A blasting gelatine to which as much as 10 per cent. of camphor has been added, cannot be made to explode completely by any known detonator, owing to the elasticity of the mass preventing the transformation of the energy into heat. Incomplete decomposition is attended with the formation of "red fumes" and other poisonous gases, containing NO_2, NO (the author in his account confuses this with *nitrous* oxide), CO and CO_2. The paper describes the medical effects of "gassing" on the men, and suggests remedies.

S. R.

680. *Existence of Free Ions in Electrolytic Solutions.* **J. Olsen.** (Amer. Journ. Sci. 14. pp. 237–248, Oct., 1902. Abstract of a thesis presented to the Graduate Faculty of Yale University for the degree of Ph.D.)—These experiments are practically an extension of one suggested by Ostwald, in which it is stated that the distribution of ions in solution may be altered by an induced electrostatic charge, and that they can then be made to give up their charges by suitable means. The author finds that if two platinum electrodes are placed in an electrolyte, the deflection which they give on a galvanometer is changed on bringing a charged body near the cell; the deflections before and after were compared over a twenty-minutes' interval. Experiments were also tried to see if an e.m.f. less than the decomposition value would alter the distribution of ions. For this purpose the deflection from the platinum electrodes in dilute sulphuric acid was observed. A Daniell cell was then applied to two terminals in the same line, but slightly further apart or closer together. After the Daniell had been on for a few minutes it was disconnected, and the deflections were again observed. They were found to be different, and the same effect was produced by e.m.f.'s of only ¼ Daniell, though a longer time was taken. The original deflection could be reversed in this way. In another experiment, two weighed copper electrodes were placed in a solution of copper sulphate. The deflection which they originally gave was reversed by an induced charge, and the cell was then short-circuited. This was continued for about three-quarters of an hour, the circuit being broken only when the charge was being renewed. At the end of this time it was found that the kathode had gained 1·2 mg., and the anode had lost 0·4 mg. These experiments, therefore, support the view that free ions exist in solution.

W. R. C.

681. *Influence of the Solvent in Electrolytic Conduction.* **H. E. Patten.** (Journ. Phys. Chem. 6. pp. 554–600, Nov., 1902.)—Measurements were made of the decrease in specific conductivity of a mixture of pyridine and acetic acid on adding various organic solvents. Similar measurements were made in the case of solutions of silver nitrate in pyridine. For chemically analogous substances the lowering of conductivity is roughly proportional to the number of gram-molecules added; it is suggested that this might be made the basis of a new method of molecular weight determination, but so far as can be seen the method would be of little use except as an adjunct to the well-known methods generally adopted. Curves are given showing the specific conductivity of solutions in acetic acid, of (1) pyridine, (2) dimethylaniline, (3) isobutylamine, (4) amylamine, (5) quinoline, and (6) aniline. The ordinates are sp. cond. × 10^3 and the abscissæ percentages by weight of the base. These curves, which are reproduced, are of considerable interest, and especially those of the strong primary bases, 3 and 4, which exhibit a double crest similar to that shown by mixtures of SO_3 and H_2O; the curve for aniline—a much weaker base—shows only a single crest, but this is prolonged very



much in the direction in which a second crest might be expected, and so perhaps represents an intermediate type of curve; the tertiary bases, pyridine, quinoline, and dimethylaniline exhibit only a single sharply marked crest. T. M. L.

682. *Contact E.M.F.* **P. Boley.** (Comptes Rendus, 135. pp. 454–455, Sept. 15, 1902.)—By measuring the e.m.f. of the cell

$$E = M/L + L/L' + L'/M' + M'/M,$$

where M stands for metal and L for liquid, and by measuring the e.m.f. of the metal/liquid junctions and making L/L′ negligible, the author arrives at a value for the contact e.m.f. M′/M. Amalgams were used, and in the case of silver-amalgam/mercury the result was 0·001 volt, which is lower than the order of the experimental errors. W. R. C.

683. *Oxydation by Electrolytic Fluorine.* **F. W. Skirrow.** (Zeitschr. Anorg. Chem. 33. 1. pp. 25–31, Nov. 18, 1902.)—The series of discharge tensions, viz., $O'' = 1{\cdot}08$, $Cl' = 1{\cdot}4$, $OH' = 1{\cdot}67$, shows that in passing a current of chlorine through water, oxygen is disengaged. The amount thus liberated, however, on account of the low concentration and the small velocity of formation of the oxygen ions, is a rather limited one. The author therefore suggests adding a substance, the electrolytic tension of which is superior to the discharge tensions of the OH′-ions, as, for instance, fluorine. In fact, oxygen then appears in the more active form of ozone, and in greater amounts. If, now, in a solution where anodic oxygen is being liberated, oxidisable substances be present, the oxidising effect of the oxygen will depend upon the potential at which oxygen is evolved. From this it is inferred that the effects produced will be mainly due to the secondary influence of discharged fluorine ions. This conclusion is first tested on some inorganic substances, viz., salts of chromium, manganese and cobalt, and carbonic acid. In the three former cases, the yield is very much greater than in a sulphuric acid solution; the attempts, however, to obtain percarbonic acid by this method failed. Some qualitative experiments finally showed that benzol and naphthalene in hydrofluoric acid solution are oxidised to a considerable extent—in fact, much more rapidly than in a sulphuric acid solution. The author considers this method to be capable of giving particularly satisfactory results with organic bodies. A. G.

684. *Electrochemical Determination of the Constitution of Silver Salts.* **H. Ley** [with **K. Schaefer**]. (Zeitschr. Elektrochem. 8. pp. 694–695, Sept. 4, 1902. Paper read before the 9th meeting of the German Electrochemical Society at Würzburg, May 10, 1902.)—The solubility of silver nitrite, of silver sulphocyanide, and of the silver salt of saccharine is decreased by adding the corresponding alkali salts to the solution, showing that the silver and sodium salts yield the same anion and are similarly constituted. As the salts are very slightly soluble, the solutions were arranged as a concentration-cell, and the e.m.f. was determined. T. M. L.

685. *Determination of Traces of Metals in Foods by Electrolysis.* **L. Medicus** [with **C. Mebold**]. (Zeitschr. Elektrochem. 8. pp. 690–694, Sept. 4, 1902. Paper read before the 9th meeting of the German Electrochemical Society at Würzburg, May 10, 1902.)—The organic matter is first

destroyed by heating with concentrated sulphuric acid (Kjeldahl) until a colour liquid results; if no mercuric oxide is used, the oxidation takes twice as long, but the subsequent separation of mercury is avoided. For the estimation of zinc the sulphuric acid solution is evaporated to dryness in a large platinum dish, redissolved (if necessary, with a little sulphuric acid) and neutralised; iron is not removed, but is converted into ferrocyanide by adding potassium cyanide, and the filtered solution is electrolysed in a Pt-dish, when the zinc is quantitatively deposited on the dish and weighed after washing with water and alcohol and drying. Copper is estimated by a very similar method, but is deposited from a solution made acid with sulphuric acid. Tin is more troublesome as it is not readily redissolved after evaporating to dryness; the method recommended is to evaporate the acid solution to about 10 c.c., precipitate with sulphuretted hydrogen, redissolve in ammonium sulphide and electrolyse. Lead is estimated by evaporating the sulphuric acid solution to dryness, dissolving the sulphate in ammonium acetate, precipitating the sulphide with sulphuretted hydrogen, redissolving in nitric acid, electrolysing the acid solution and weighing the lead peroxide deposited on the anode. Mercury cannot be satisfactorily estimated in this way; only two-thirds of the mercury was recovered after destroying organic matter, and it is suggested that mercury amino-compounds are formed.

T. M. L.

686. *Electrolytic Manufacture of Chlorine and Alkali.* **F. Glaser.** (Zeitschr. Elektrochem. 8. pp. 552–558, Aug. 7, 1902. Communicated by the Physikalisch-chemischen Laboratorium der technischen Hochschule, Karlsruhe.)—The author constructed a small experimental cell which resembled as closely as possible the large cells employed in the Solvay-Kellner mercury process for the manufacture of chlorine and of soda or potash, and with this cell he made a study of the process with the following results: (1) Loss of current is due chiefly to the depolarising action of the chlorine on the alkali-amalgam; loss due to decomposition of the water is of minor importance. (2) Good yields are usually to be obtained only when heavy currents are employed; nevertheless, satisfactory yields can also be obtained with small current densities, if suitable diaphragms (of colloidal silicic acid, for example) be placed in or near the quicksilver kathode. D. H. J.

REFERENCES.

687. *The Argon Group.* **H. P. Talbot.** (Technology Quarterly, 15. pp. 195–228, June, 1902. Paper read before the North-eastern Section of the American Chemical Society, Feb. 27, 1902.)—This is a historical summary of investigations in this subject. G. W. DE T.

688. *Primary Batteries.* **Tuch.** (Archiv Post Tele. 13. pp. 399–404, July, and 15. pp. 474–481, Aug., 1902.)—This is a useful historical account of the various primary batteries, exclusive of "dry" cells, which from 1852 to the present time have done service at the Hamburg telegraph office successively. The author describes each cell, and assigns the reasons for their being superseded. The latter part of the paper is concerned almost entirely with the Leclanché cell and an account of experiments as to details of its construction. The Leclanché cell, in one form or another, has held the field since 1866. R. A.